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Research Article

Additions to the *Entoloma* (Agaricales, Entolomataceae) from China: Description of five species with one new to science

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Abstract

Entoloma is one of the top three genera in species diversity of Agaricomycotina. In this study, five species from Qilian Mountain in China were documented. One new species *E. griseopileum* belonging to subg. *Leptonia* was introduced based on morphological and phylogenetic analyses. This new species is characterized by its gray basidiomes with fibrillose pileus and wood-decaying lifestyle. Four known species are *E. glaucobasis*, *E. incanum*, and *E. verae* in subg. *Cyanula*, and *E. fuligineocinereum* in subg. *Nolanea*. All five species are documented with descriptions, photo plates, and molecular data including ITS, LSU, and mtSSU sequences.

Key words: Entolomataceae, new taxa, phylogeny, taxonomy

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Introduction

Entoloma (Fr.) P. Kumm., typified by *E. sinuatum* (Bull.) P. Kumm., is one of the top three genera in species diversity of Agaricomycotina. It is estimated that there are more than 1800 species of *Entoloma* worldwide (He et al. 2019a). The general morphological characteristics of *Entoloma*are:basidiomes agaricoid, secotioid or gasteroid; agaricoid habit variable as tricholomatoid, mycenoid, collybioid, clitocyboid, omphalioid or pleurotoid; pink spore print or pinkish brown, lamellae almost free, adnexed to adnate, adnate-emarginate or adnate-decurrent, spores angular in all views which is entirely covered with facets delineated by ridges; clamp-connections often absent; cheilocystidia rare; pileipellis variable (cutis, trichoderm, hymeniderm) with diverse pigmentation(Noordeloos 1981; Largent 1986). Most species of this genus are saprotrophic, but there are also some mycorrhizal or weakly parasitic taxa. For example, members of sections *Entoloma* and *Rhodopolia* are ectomycorrhizal, and Rosaceae-associated members of section *Nolanidea* are considered weakly parasitic (Agerer and Waller 1993; Tedersoo et al. 2010).

A robust molecular-based taxonomic system for *Entoloma* is not established yet. Traditional taxonomic studies divided *Entoloma* into 13 subgenera based on morphological characteristics, such as basidiome forms, pileipellis, basidiospores, cystidia, and clamp connections (Noordeloos and Gates 2012a; Kaygusuz et al. 2024). Another opinion treated these subgenera as genera (Aime et al. 2010, Karstedt et al. 2020; Niveiro et al. 2021). *Entoloma* constitutes the dominant species diversity within Entolomataceae. The first comprehensive molecular phylogenetic study of Entolomataceae indicated there are two main clades of *Entoloma*, basal and crown clades. The basal clade is equal to Prunuloides clade and crown clade is composed of Rhodopoloid clade, *Inocephalus-Cyanula* clade, and *Nolanea-Claudopus*. Subgenus *Leptonia* is found to be polyphyletic and distributed in two different subclades in the crown clade (Co-David et al. 2009).

In the past decades, most taxonomic studies of *Entoloma* are focused on American and European areas while species diversity of *Entoloma* in China is relatively poorly known. In recent years, species diversity of *Entoloma* in China has been explored.There are many new species of *Entoloma* introduced from China based on morphological and molecular data (He et al. 2012, 2013, 2015, 2019b; Chen et al. 2024, 2025). The Qilian Mountains, located between Qinghai and Gansu provinces in northwest China, is a critical biodiversity corridor connecting northern and southern China. During our macrofungi diversity surveys in Qilian Mountains, several notable samples of *Entoloma* were collected. In this study, based on morphological and multigene phylogenetic analyses, we identified and documented five *Entoloma* species including one new to science in subgenus *Leptonia*.

Materials and methods

Morphological examination

Specimens were collected during the rainy season (July to August). Photographs were taken immediately in the field. Basidiomes were wrapped in aluminium foil or put in plastic boxes separately. Macro morphological characteristics and habit information were recorded when specimens were fresh. Every specimen was dried in an electrical food drier at 40 °C, then kept in a plastic ziplock bag and deposited in Herbarium MycologicumAcademiaeSinicae (HMAS). Anatomical and cytological characteristics were observed using dry specimens under the light microscope (SOPTOP EX33). Observed characteristics included basidiospores, basidia, cystidia and pileipellis. At least 20 measurements were made for each characteristic. Measurements were analyzed and recorded as X = the mean of length by width ± SD, Q = the quotient of basidiospore length to width, and Q_m = the mean of Q values ± SD. All the protocols of morphological study followed Largent's methodology (Largent 1986).

DNA extraction and PCR

Genomic DNA of each specimen was extracted by abroad-spectrum plant Rapid Genomic DNA Kitfollowed the manufacturer's protocol. Three genes were applied in the phylogenetic analyses viz. internal transcribed spacer (ITS), large ribosomal subunit (LSU), and mitochondrial ribosomal small subunit (mtSSU). The primers for each gene are ITS4/ITS5, LR5/LROR, and NS1/NS4, respectively.

The PCR programs are followed describe in He et al. (2017). The PCR products were sequenced in Sangon Biotech (Shanghai) Co., Ltd. Both directions were sequenced to ensure accuracy of each gene.

Phylogenetic analyses

Information of reference and new generated sequences were listed in Suppl. material 1. New generated sequences were checked in Geneious Prime v.2025.0.3. Alignments were made using Muscle for each gene separately (Edgar 2004), then adjusted by hand to remove the ambiguous region. The dataset was made for genus *Entoloma*. The *Entoloma*dataset includes 72ITS, 53LSU, and 43mtSSU. Maximum likelihood (ML) analysis and bootstrap values calculation were performed in raxmlGUI 1.5b1 with GTRGAMMA model with 1000 replicates (Silvestro and Michalak 2012). ModelFinder v2.2.0 (Kalyaanamoorthy et al. 2017) was used to select the best-fit partition model (Edge-linked) using AIC criterion. In the *Entoloma* dataset, Best-fit model according to AIC are GTR+F+I+G4 for ITS, GTR+F+I+G4 for LSU, and GTR+F+I+G4 for mtSSU. Bayesian Inference (BI) analysis was performed by MrBayes 3.1.2. Ten million generations were run for six Markov chains and sampled every 1000th generation. Burn-ins was determined in Tracer v1.6 with effective sample sizes (ESS) higher than 200 (http://tree.bio.ed.ac.uk/software/tracer). Remaining trees were used to calculate Bayesian posterior probabilities (PP). Maximum likelihood (ML) analysis and bootstrap values calculation were performed in raxmlGUI 1.5b1 with GTRGAMMA model with 1000 replicates (Silvestro and Michalak 2012). Phylogenetic trees were presented in Fig. 1.

Phylogenetic results

The ML tree of *Entoloma* is presented in Fig. 1. There are 75 samples involved representing 48 species of *Entoloma* and one outgroup species *Clitopilus hirneolus*. These 48 species represent twelve subgenera of *Entoloma*. Samples collected from Qilian Mountains distributed in three subgenera, viz. subg. *Cyanula*, subg. *Nolanea*, subg. *Leptonia*. In the *Cyanula* clade, three samples from Qilian Mountains clustered in *E. incanum*, *E. verae*,and *E. glaucobasis* clades with full bootstrap values. Four samples clustered in *E. fuligineocinereum* clade in subg. *Nolanea* with full bootstrap and PP values. Three samples clustered in *Entoloma* and sister to the *E. tallingiorum* with the statistical values PP/BS = 1.0/99.Three Qinghai samples clustered together and sister to the clade composed by *E. austriacum*, *E. alnetorum*,and *E. tjallingiorum* with the statistical values PP/BS = 1.0/100.

Taxonomy

***Entoloma fuligineocinereum* Mešić & Tkalčec, Phytotaxa 289(3): 297 (2016)**
Fig. 2

Basionym. *Nolanea latifolia* Kauffman, Pap. Mich. Acad. Sci. 5: 140, 1926 [1925].

Description. Pileus is 23.0–32.2 mm in diameter, convex or broadly convex, occasionally umbonate on the disc, margin entire, occasionally straight; dry orhygrophanous, smooth, background gray or dark brown. *Lamellae* up to 3 mm broad, adnate or slightly sinuate, light brown, brown, getting dark near the

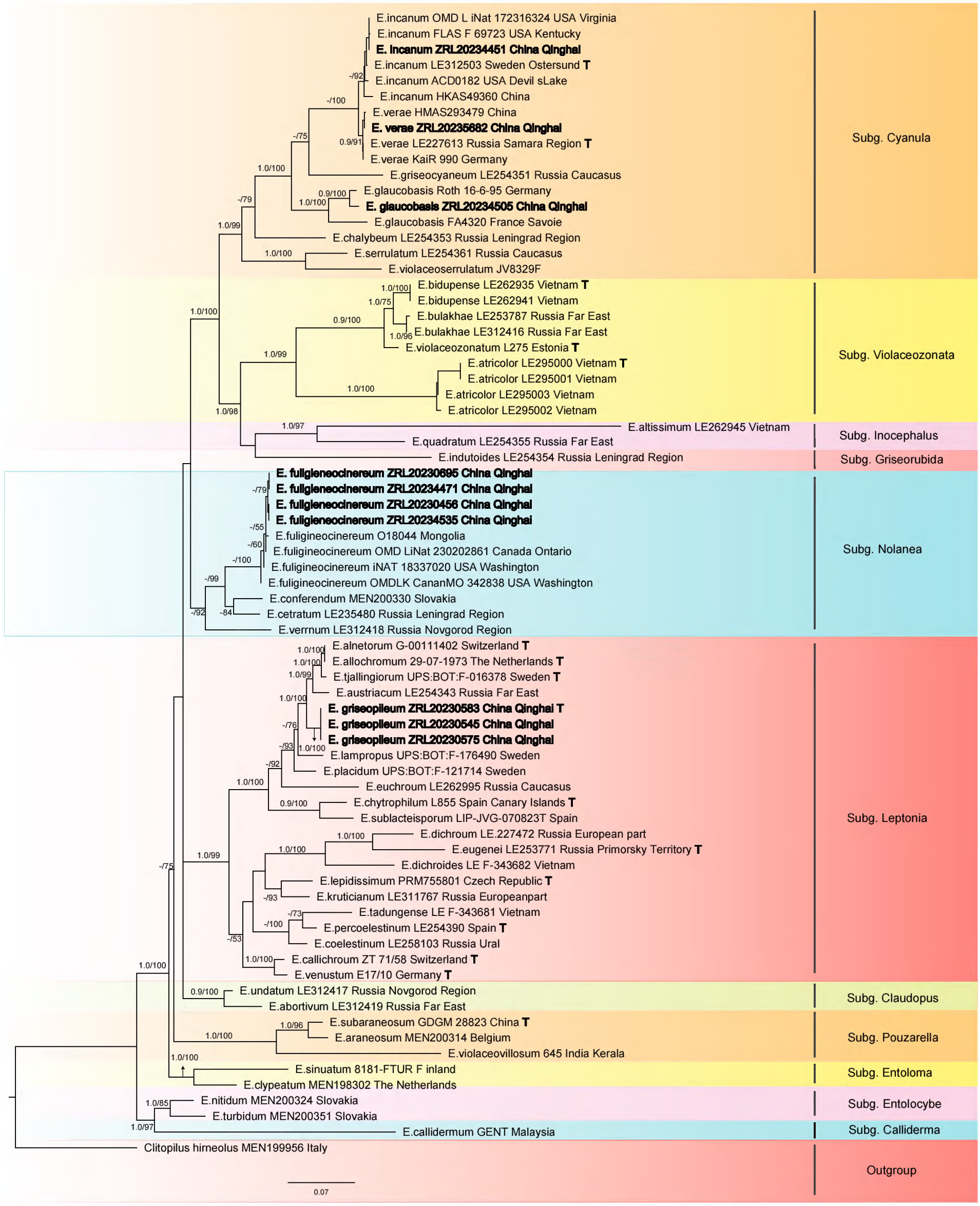
E.incanum OMD L iNat 172316324 USA Virginia
E.incanum FLAS F 69723 USA Kentucky
E. incanum ZRL20234451 China Qinghai
E.incanum LE312503 Sweden Ostersund T
E.incanum ACD0182 USA Devil sLake
E.incanum HKAS49360 China
E.verae HMAS293479 China
E. verae ZRL20235682 China Qinghai
E.verae LE227613 Russia Samara Region T
E.verae KaiR 990 Germany
E.griseocyaneum LE254351 Russia Caucasus
E.glaucobasis Roth 16-6-95 Germany
E. glaucobasis ZRL20234505 China Qinghai
E.glaucobasis FA4320 France Savoie
E.chalybeum LE254353 Russia Leningrad Region
E.serrulatum LE254361 Russia Caucasus
E.violaceoserrulatum JV8329F
Subg. Cyanula
E.bidupense LE262935 Vietnam T
E.bidupense LE262941 Vietnam
E.bulakhae LE253787 Russia Far East
E.bulakhae LE312416 Russia Far East
E.violaceozonatum L275 Estonia T
E.atricolor LE295000 Vietnam T
E.atricolor LE295001 Vietnam
E.atricolor LE295003 Vietnam
E.atricolor LE295002 Vietnam
Subg. Violaceozonata
E.altissimum LE262945 Vietnam
E.quadratum LE254355 Russia Far East
Subg. Inocephalus
E.indutoides LE254354 Russia Leningrad Region
Subg. Griseorubida
E. fuligineocinereum ZRL20230695 China Qinghai
E. fuligineocinereum ZRL20234471 China Qinghai
E. fuligineocinereum ZRL20230456 China Qinghai
E. fuligineocinereum ZRL20234535 China Qinghai
E.fuligineocinereum O18044 Mongolia
E.fuligineocinereum OMD LiNat 230202861 Canada Ontario
E.fuligineocinereum iNAT 18337020 USA Washington
E.fuligineocinereum OMDLK CananMO 342838 USA Washington
E.conferendum MEN200330 Slovakia
E.cetratum LE235480 Russia Leningrad Region
E.verrnum LE312418 Russia Novgorod Region
Subg. Nolanea
E.alnetorum G-00111402 Switzerland T
E.allochromum 29-07-1973 The Netherlands T
E.tjallingiorum UPS:BOT:F-016378 Sweden T
E.austriacum LE254343 Russia Far East
E. griseopileum ZRL20230583 China Qinghai T
E. griseopileum ZRL20230545 China Qinghai
E. griseopileum ZRL20230575 China Qinghai
E.lampropus UPS:BOT:F-176490 Sweden
E.placidum UPS:BOT:F-121714 Sweden
E.euchroum LE262995 Russia Caucasus
E.chytrophilum L855 Spain Canary Islands T
E.sublacteisporum LIP-JVG-070823T Spain
E.dichroum LE.227472 Russia European part
E.eugenei LE253771 Russia Primorsky Territory T
E.dichroides LE F-343682 Vietnam
E.lepidissimum PRM755801 Czech Republic T
E.kruticianum LE311767 Russia Europeanpart
E.tadungense LE F-343681 Vietnam
E.percoelestinum LE254390 Spain T
E.coelestinum LE258103 Russia Ural
E.callichroum ZT 71/58 Switzerland T
E.venustum E17/10 Germany T
Subg. Leptonia
E.undatum LE312417 Russia Novgorod Region
E.abortivum LE312419 Russia Far East
Subg. Claudopus
E.subaraneosum GDGM 28823 China T
E.araneosum MEN200314 Belgium
E.violaceovillosum 645 India Kerala
Subg. Pouzarella
E.sinuatum 8181-FTUR F inland
E.clypeatum MEN198302 The Netherlands
Subg. Entoloma
E.nitidum MEN200324 Slovakia
E.turbidum MEN200351 Slovakia
Subg. Entolocybe
E.callidermum GENT Malaysia
Subg. Calliderma
Clitopilus hirneolus MEN199956 Italy
Outgroup
0.07

Figure 1. Maximum likelihood tree of *Entoloma* based on ITS, LSU, and mtSSU genes, rooted with *Clitopilus hirneolus*. Bayesian posterior probability (PP) values ≥ 90% or Bootstrap support (BS) values ≥ 50% are indicated at the internodes (PP/BS). New samples are in bold.The type strains cited indicated by a bold "T".

pileus edge, eroded,veined. Stipe 72.4–80.2 × 3.2–3.8 mm, concolor with the pileus, paler toward base, cylindrical,equal, surface dry, smooth, silky, occasionally with the white fibrils or punctate near the pileus.

Figure 2. *Entoloma fuligineocinereum*. **a, b.** Basidiomes in the field; **c–g.** Basidia; **h, i.** Basidiospores; **j.** Pileipellis hyphae; **k, l.** Lamellae edge. Scale bars: 5 mm (**a, b**); 5 µm (**c–g**); 10 µm (**h–l**); 40 µm (**j**); 5 µm (**k, l**).

Basidiospores 8.6–11.6 × 8.1–9.8 µm [$\bar{x}$ =9.6 ± 0.7 × 8.7 ± 0.4 µm, Q = 1.0–1.2, Q_m = 1.1 ± 0.1, n = 20], subglobose-angular, asymmetrical, with 5–7 side. Basidia 40.7–47.9 × 11.2–13.2 µm, 4-spored. Cheilocystidia absent. Pileipellis a cutis with a transition to a plagiotrichoderm and a trichoderm of cylindrical to slightly inflated hyphae14.2–28.9 µm wide, with lightmembranous brown pigment. Clamp connections absent. Lamellae edge is fertile.

Notes. Our samples clustered with samples from Northern America and Mongolia of *E. fuligineocinereum* in the phylogenetic tree (Fig. 1). Morphologically, the morphological characteristics of our samples differs slightly from the previous descriptions. Basidiomes color of our samples is paler than those described in Largent (1971). In addition, our Chinese samples present slightly larger basidiospores compared with the holotype (7.5–9 × 7–8.5 µm, $\bar{x}$ = 8.3 × 7.7 µm, Largent 1971).

Specimen examined. CHINA • Qinghai province, Qilian Mountain National Park, Sigou, Donghaikou, 9 July 2023, MQ He, *ZRL20230456* (HMAS300882) • Qinghai Province, Haibei Tibetan Autonomous Prefecture, Qilian County, Binggoulinhai, 15 July 2023, MQ He, *ZRL20230695* (HMAS300880) • Qinghai Province, Tongren City, ZamaoKasuhu, 23 August 2023, MQ He, *ZRL20234471* (HMAS300879) • Qinghai Province, Huangnan Tibetan Autonomous Prefecture, Maixiu Forest Farm, 22 August 2023, MQ He, *ZRL20234535* (HMAS300881).

***Entoloma glaucobasis* Huijsman ex Noordel., Persoonia 12(4): 260 (1985)**
Fig. 3

Description. Pileus 29–33.4 mm in diameter, campanulate, occasionally with a broad umbo, disc depressed or deeply indented, margin entire, straight, slightly uplifted; surfacedry, background gray or light brown, covered with brown fibrillose scales in triangular shape, scales denser and darker at the disc. *Lamellae* up to 4 mm broad, adnate to decurrent, subdistant, white, light pink, entire, veined. Stipe 48.1–59.6 × 2.3–2.5 cm, light brown, concolor with the pileus, surface dry, smooth, base white with hypha.

Basidiospores 9.3–12.0 × 6.7–9.2 µm [$\bar{x}$ =10.7 ± 0.7 × 8.1 ± 0.6 µm, Q = 1.2–1.6, Q_m = 1.3 ± 0.1, n = 20], heterodiametric, with 5–7 angles in side-view. Basidia 28.5–38.6 × 9.8–13.6 µm, 4-spored. Cheilocystidia basidia-like, 13.2–19.8 × 3.7–7.4 µm.Pileipellis a cutis with a transition to a plagiotrichoderm and a trichoderm of cylindrical to slightly inflated hyphae 8.2–17.9 µm wide, hyaline, membranous light brown. Clamp connections absent. Lamellae edge is heterogeneous.

Notes. A sample from Qilian Mountain clustered two European samples of *E. glaucobasis*in the phylogenetic tree (Fig. 1). This species is originally described from Germany. Our sample generally coincides with the original description of *E. glaucobasis*. Difference is that the cheilocystidia is basidia-like in our sample while is clavate or vesicular according to the original description (Noordeloos 1985).

Specimen examined. CHINA • Qinghai Province, Huangnan Tibetan Autonomous Prefecture, Maixiu Forest Farm, 22 August 2023, MQ He, *ZRL20234505* (HMAS300878).

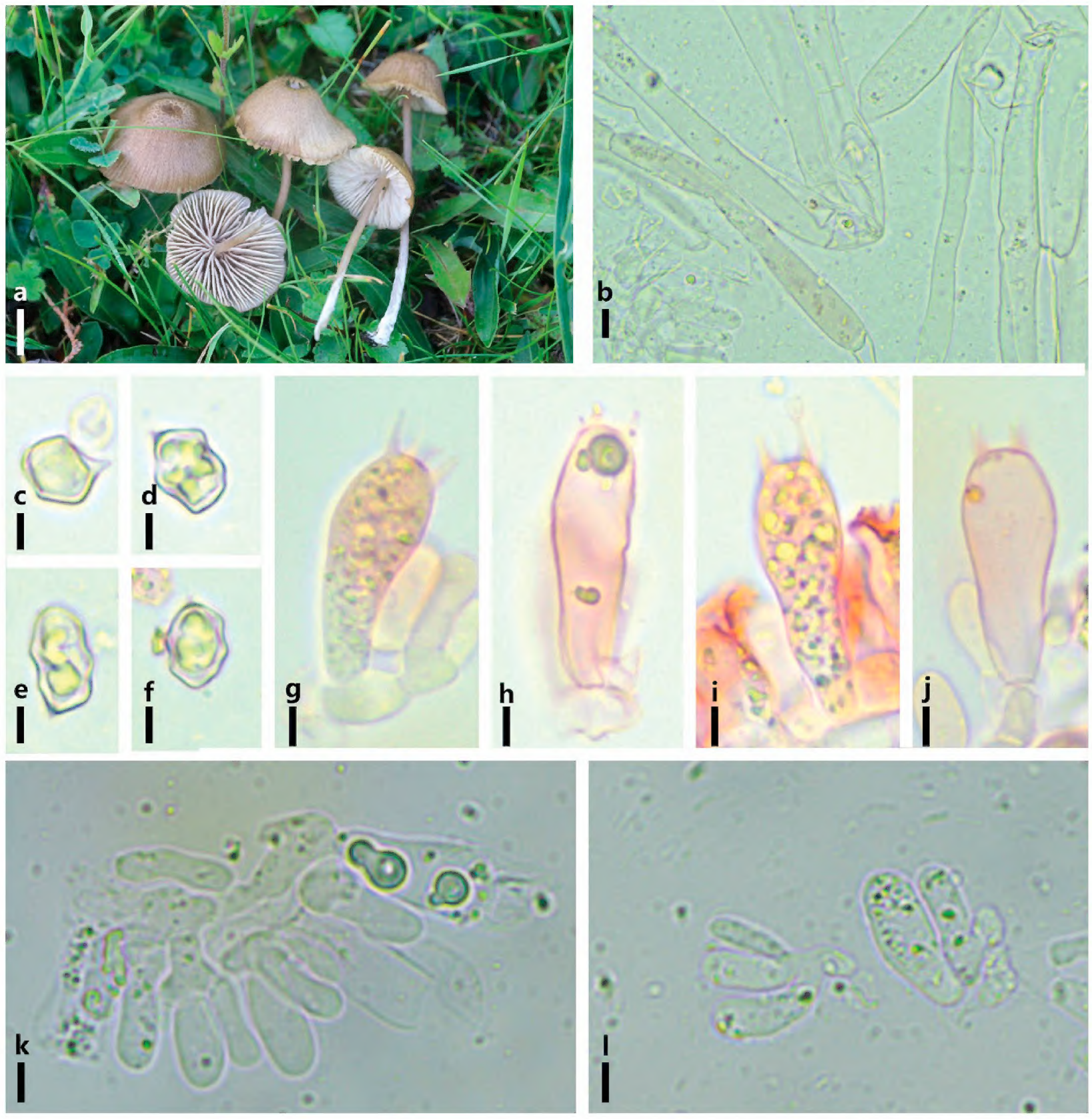

Figure 3. *Entoloma glaucobasis*. **a.** Basidiomes in the field; **b.** Pileipellis hyphae; **c–f.** Basidiospores; **g–j.** Basidia; **k–i.** Cheilocystidia. Scale bars: 5 mm (**a**); 10 µm (**b**); 5 µm (**c–f**); 5 µm (**g–j**); 5 µm (**k, l**).

Entoloma griseopileum M.Q. He & X. Liu, sp. nov.

Fungal Names: FN 572836

Fig. 4

Etymology. the epithet "*griseo*" means gray, the name refers to the grayish pileus.

Holotype. CHINA • Qinghai Province Mutual Aid County, Beishan National Forest Park,Langshidang, 10 July 2023, MQ He,*ZRL20230583* (HMAS300884).

Diagnosis. This species is characterized by its gray basidiomes and fibrillose pileus.

Original description. Pileus is 26–32 mm in diameter, broadly convex, umbonate on the disc, margin slightly decurved when young, getting straight or slightly uplifted when mature; surface dry, fibrillose, background gray, fibrils light brown, denser and darker on the disc. *Lamellae* up to 3 mm broad, adnate or slightly sinuate, eroded, white, slightly pink, getting brown or dark brown near the pileus edge. Stipe 33.53–42.20 × 3.2–3.5 mm, concolor with the pileus, darker toward base, cylindrical,equal,surface dry, smooth, silky, occasionally with the same fibrils as on pileus.

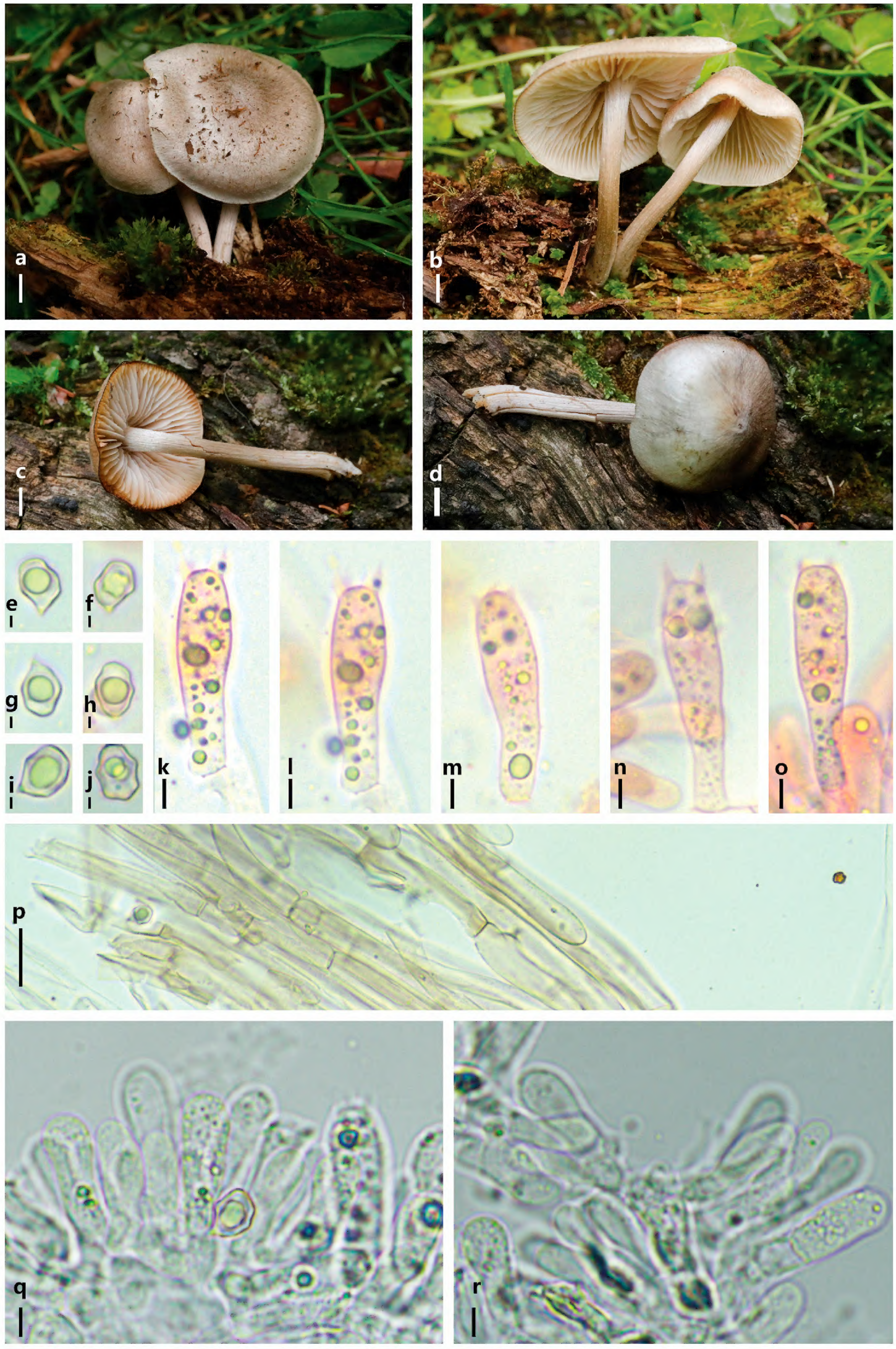

Figure 4. *Entoloma griseopileum*. **a–d.** Basidiomes in the field; **e–j.** Basidiospores; **k–o.** Basidia; **p.** Pileipellis hyphae; **q–r.** Lamellae edge. Scale bars: 5 mm (**a–d**); 2 µm (**e–j**); 5 µm (**k–o**); 10 µm (**p**); 5 µm (**q–r**).

Basidiospores 6.8–10.1 × 5.9–7.7 µm [$\bar{x}$ =8.9 ± 0.7 × 6.7 ± 0.4 µm, Q = 1.0–1.6, Q_m = 1.3 ± 0.1, n = 20], heterodiametric, with 5–7 angles in side-view. Basidia 31.8–40.6 × 9.3–13.8 µm, 4-spored. Cheilocystidia absent. Pileipellis a cutis with a transition to a plagiotrichoderm and a trichoderm of cylindrical to slightly inflated hyphae 4.6–11.1 µm wide, with membranous brown pigment. Clamp connections absent. Lamellae edge is fertile.

Habitat. Wood-inhabiting.

Notes. Morphologically, *E. griseopileum* resembles *E. bisporigerum* in the field which also can be found in northern China (Li et al. 2015). Both species have grayish small basidiomes (pileus smaller than 4cm in diameter). But under microscope, *E. bisporigerum* can be distinguished from *E. griseopileum* by its larger basidiospores (11.5–13.5 × 7.5–9 µm). Furthermore, *E. bisporigerum* grows on soil, while *E.griseopileum* grows on wood.

Other specimens examined. CHINA • Qinghai Province, Beishan National Forest Park, Langshidang, 10 July 2023, MQ He, *ZRL20230545* (HMAS300885), *ZRL20230575* (HMAS300883).

***Entoloma incanum* (Fr.) Hesler,Beih. Nova Hedwigia 23: 147 (1967)**

Fig. 5

Description. Pileus is 22.9–26.0 mm in diameter, broadly convex, disc depressed to deeply indented, margin entire;surfacesmooth or slightly with white fibrils, brown, yellowish brown, darker at the disc, getting paler or yellower towards the edge. *Lamellae* up to 3 mm broad, adnate to decurrent, subdistant, white, light yellow,entire,veined. Stipe 53.6 × 6.6 mm, yellow, or light greenish yellow, hollow,compressed, surface dry, smooth, base white with hypha.

Basidiospores 9.8–13.6 × 6.3–8.4 µm [$\bar{x}$ =11.6 ± 1.1 × 7.4 ± 0.6 µm, Q = 1.3–2.0, Q_m = 1.6 ± 0.2, n = 20], heterodiametric, with 6–8 angles in side-view. Basidia 40.3–60.8 × 10.2–15.9 µm, 4-spored. Cheilocystidia absent. Pileipellis a cutis with a transition to a plagiotrichoderm and a trichoderm of cylindrical to slightly inflated hyphae 6.0–15.5 µm wide, with membranous light brown pigment. Clamp connections absent. Lamellae edge is fertile.

Notes. Our Chinese samples clustered with northern America samples of *E. incanum* in the phylogenetic tree with full statistical values (Fig. 1). *Entoloma incanum* is a remarkable species in the field due to its greenish-brown or yellowish-brown basidiomes with a bright stipe in green or yellow. Our samples present a relatively browner pileus than American samples (Kuo 2013).

Specimen examined. CHINA • Qinghai Province, Tongren City, Zhamao Village, 23 August 2023, MQ He, *ZRL20234451* (HMAS300876).

***Entoloma verae* O.V. Morozova, Noordel., Reschke, F. Salzmann & Dima, Persoonia 47: 307 (2021)**

Fig. 6

Description. Pileus 21.4 mm in diameter, plane, disc deeply indented, margin entire, surfacedry, with distinct radial dark brown fibrils on pale background,sometimes cracked when dry or old, pileus edge dark brown. *Lamellae*

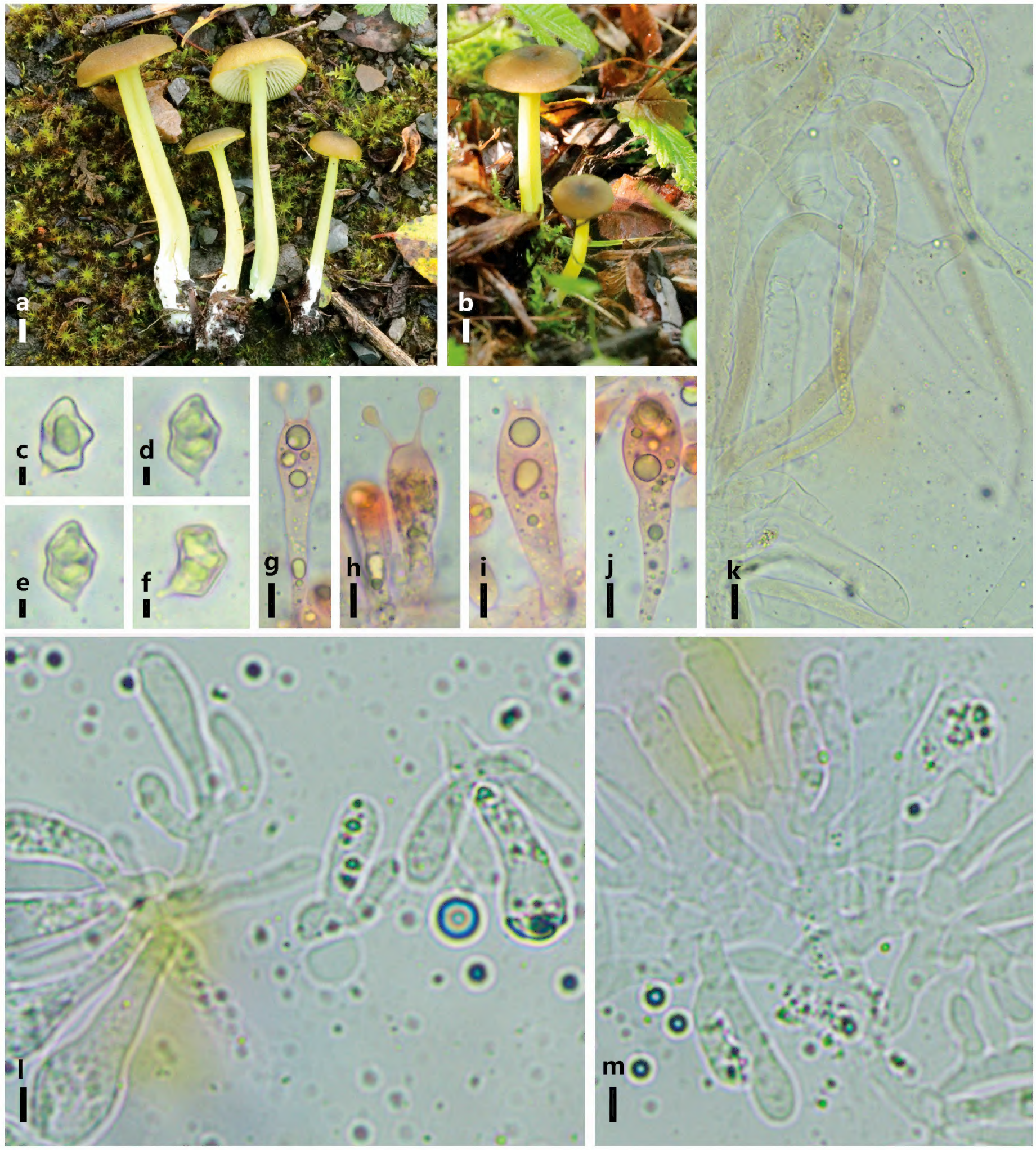

Figure 5. *Entoloma incanum*. **a, b.** Basidiomes in the field; **c–f.** Basidiospores; **g–j.** Basidia; **k.** Pileipellis hyphae; **i–m.** Lamellae edge. Scale bars: 5 mm (**a, b**); 2 µm (**c–f**); 10 µm (**g–j**); 20 µm (**k**); 2 µm (**l, m**).

up to 4 mm broad, adnate to decurrent, subdistant, yellowish white and light pink,entire,veined. Stipe 36.4 × 2.2 cm, green, yellowish green,equal, surface dry, with yellow tiny fibrils, base white with hypha, staining bright greenish blue when bruised.

Basidiospores 8.9–12.5 × 5.8–8.0 µm [$\bar{x}$ = 10.9 ± 0.9 × 7.2 ± 0.5 µm, Q = 1.2–1.8, Q_m = 1.5 ± 0.1, n = 20], heterodiametric, with 6–7 angles in side-view. Basidia 31.6–43.4 × 12.4–17.4 µm, 4-spored. Cheilocystidia not observed. Pileipellis a cutis with a cylindrical to slightly inflated hyphae 4.5–14.5 µm wide, hyaline. Membranous pigment. Clamp connections absent.

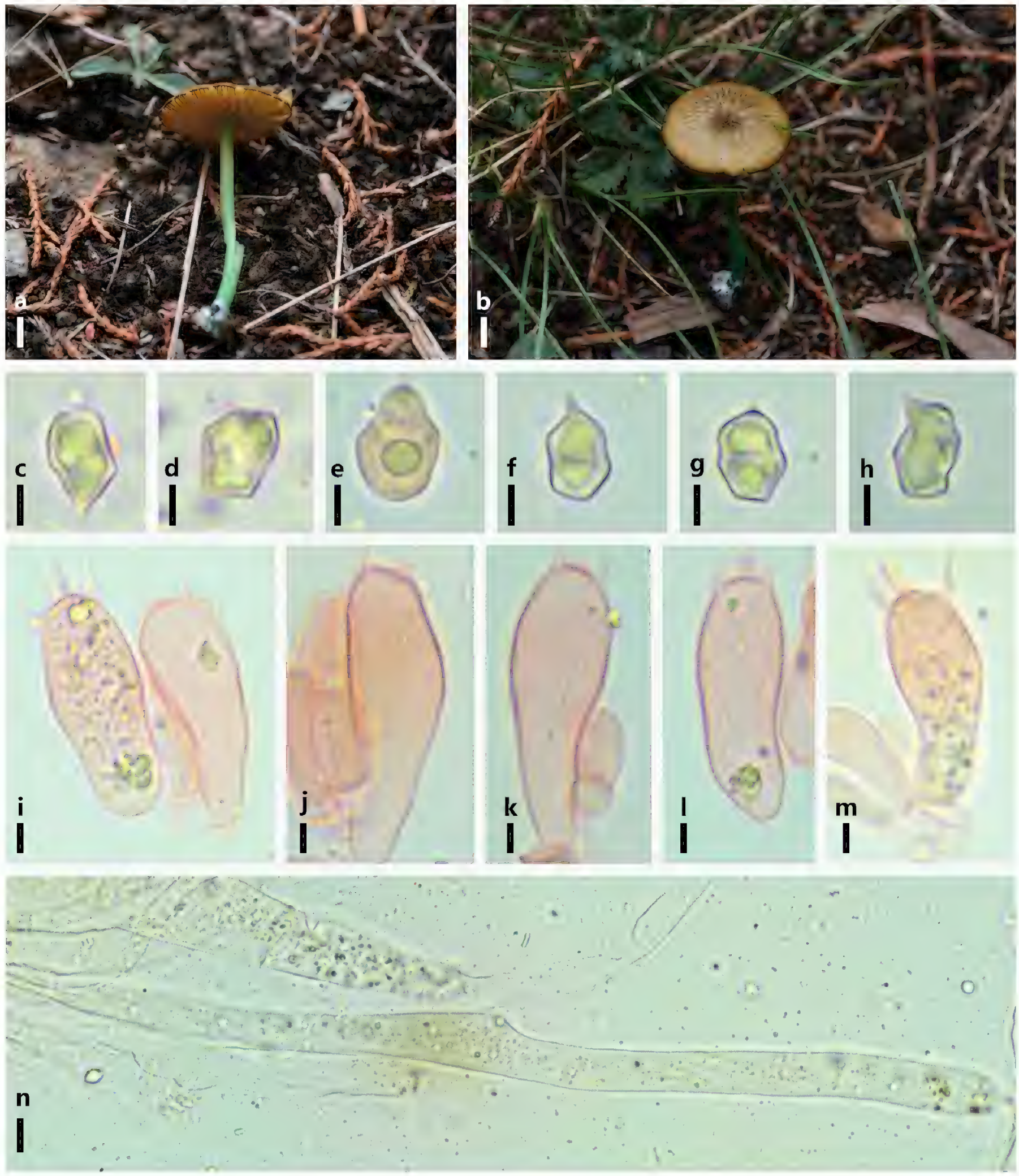

Figure 6. *Entoloma verae*. **a, b.** Basidiomes in the field; **c–h.** Basidiospores; **i–m.** Basidia; **n.** Pileipellis hyphae. Scale bars: 5 mm (**a, b**); 5 µm (**c–h**); 5 µm (**i–m**); 10 µm (**n**).

Notes. Our sample clustered with European samples including the type of *E.verae* in the phylogenetic tree with full statistical values. Morphological characteristics of our sample generally coincides with the original description. Small differences are pileus color and basidiospore size. The pileus of our sample is darker and the basidiospore is smaller compared to the original description (Crous et al. 2021).

Specimen examined. CHINA • Qinghai province, Haidong City, Tu Autonomous County of Huzhu, Ganchan Temple, 26 August 2023, MQ He, *ZRL20235682* (HMAS300877).

Conclusions

In this study, five *Entoloma* species were documented from China. These include one new species, *E. griseopileum*in subg. *Leptonia*. The new species is characterized by its gray basidiomes, fibrillose pileus, and wood-decaying habit. The other four known species are *E. glaucobasis*, *E. incanum*, and *E. verae* in subg. *Cyanula*, and *E. fuligineocinereum* in subg. *Nolanea*. All five species are found in the Qilian Mountains. The macrofungal diversity of this region has been explored in recent years, and many new species, for example, from *Agaricus*, *Cystoderma*, and *Lyophyllum*, have been found and documented (Zhang et al. 2017; Li et al. 2021; Wei et al. 2023). We assumed that there would be continuous descriptions of species from this region as it is part of the Qinghai-Xizang Plateau and is a critical biodiversity corridor connecting northern and southern China.

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Use of AI

No use of AI was reported.

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Author contributions

The sampling work was completed by Xixi Han, Rui Xing, Ruilin Zhao and Maoqiang He. The data collection and analyses were completed by Xu Liu, Qiang Chen, Quanju Xiang and Yunfu Gu. The draft was made and edited by Xu Liu. All authors have reviewed and agreed to publish the current version of the manuscript.

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Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

References

Agerer R, Waller K (1993) Mycorrhizae of *Entoloma saepium*: Parasitism or symbiosis? Mycorrhiza 3: 145–154. https://doi.org/10.1007/BF00203608

Aime F, Johnson SW, Ridge JD, Hill A (2010) The routine may be stable but the advantage is not: Competitive implications of key employee mobility. Strategic Management Journal 31(1): 75–87. https://doi.org/10.1002/smj.809

Chen LG, Ding L, Chen H, Zeng H, Zeng ZH, Wang SN, Yan JQ (2024) Seven New Species of *Entoloma* Subgenus *Cubospora* (Entolomataceae, Agaricales) from Subtropical Regions of China. Journal of Fungi (Basel, Switzerland) 10(8): 594. https://doi.org/10.3390/jof10080594

Chen LG, Chen H, Ding L, Xu YQ, Zeng H, Wang SN, Yan JQ (2025) Four new species of *Entoloma* subgenus *Cyanula* (Entolomataceae, Agaricales) from subtropical regions of China. MycoKeys 116: 303. https://doi.org/10.3897/mycokeys.116.145568

Co-David D, Langeveld D, Noordeloos ME (2009) Molecular phylogeny and spore evolution of Entolomataceae. Persoonia-Molecular Phylogeny and Evolution of Fungi 23(1): 147–176. https://doi.org/10.3767/003158509X480944

Crous PW, Osieck ER, Jurjević Ž, Boers J, van Iperen AL, Starink-Willemse M, Dima B, Balashov S, Bulgakov TS, Johnston PR, Morozova OV, Pinruan U, Sommai S, Alvarado P, Decock CA, Lebel T, McMullan-Fisher S, Moreno G, Shivas RG, Zhao L, Abdollahzadeh J, Abrinbana M, Ageev DV, Akhmetova G, Alexandrova AV, Altés A, Amaral AGG, Angelini C, Antonín V, Arenas F, Asselman P, Badali F, Baghela A, Bañares A, Barreto RW, Baseia IG, Bellanger JM, Berraf-Tebbal A, Biketova AY, Bukharova NV, Burgess TI, Cabero J, Câmara MPS, Cano-Lira JF, Ceryngier P, Chávez R, Cowan DA, de Lima AF, Oliveira RL, Denman S, Dang QN, Dovana F, Duarte IG, Eichmeier A, Erhard A, Esteve-Raventós F, Fellin A, Ferisin G, Ferreira RJ, Ferrer A, Finy P, Gaya E, Geering ADW, Gil-Durán C, Glässnerová K, Glushakova AM, Gramaje D, Guard FE, Guarnizo AL, Haelewaters D, Halling RE, Hill R, Hirooka Y, Hubka V, Iliushin VA, Ivanova DD, Ivanushkina NE, Jangsantear P, Justo A, Kachalkin AV, Kato S, Khamsuntorn P, Kirtsideli IY, Knapp DG, Kochkina GA, Koukol O, Kovács GM, Kruse J, Kumar TKA, Kušan I, Læssøe T, Larsson E, Lebeuf R, Levicán G, Loizides M, Marinho P, Luangsa-Ard JJ, Lukina EG, Magaña-Dueñas V, Maggs-Kölling G, Malysheva EF, Malysheva VF, Martín B, Martín MP, Matočec N, McTaggart AR, Mehrabi-Koushki M, Mešić A, Miller AN, Mironova P, Moreau PA, Morte A, Müller K, Nagy LG, Nanu S, Navarro-Ródenas A, Nel WJ, Nguyen TH, Nóbrega TF, Noordeloos ME, Olariaga I, Overton BE, Ozerskaya SM, Palani P, Pancorbo F, Papp V, Pawłowska J, Pham TQ, Phosri C, Popov ES, Portugal A, Pošta A, Reschke K, Reul M, Ricci GM, Rodríguez A, Romanowski J, Ruchikachorn N, Saar I, Safi A, Sakolrak B, Salzmann F, Sandoval-Denis M, Sangwichein E, Sanhueza L, Sato T, Sastoque A, Senn-Irlet B, Shibata A, Siepe K, Somrithipol S, Spetik M, Sridhar P, Stchigel AM, Stuskova K, Suwannasai N, Tan YP, Thangavel R, Tiago I, Tiwari S, Tkalčec Z, Tomashevskaya MA, Tonegawa C, Tran HX, Tran NT, Trovão J, Trubitsyn VE, Van Wyk J, Vieira WAS, Vila J, Visagie CM, Vizzini A, Volobuev SV, Vu DT, Wangsawat N, Yaguchi T, Ercole E, Ferreira BW, de Souza AP, Vieira BS, Groenewald JZ (2021) Fungal Planet description sheets: 1284–1382. Persoonia: Molecular Phylogeny and Evolution of Fungi 47: 178.10.3767/persoonia.2021.47.06

Edgar RC (2004) MUSCLE: Multiple sequence alignment with high accuracy and high throughput. Nucleic Acids Research 32(5): 1792–1797. https://doi.org/10.1093/nar/gkh340

He XL, Li TH, Shen YH (2012) Four new species of *Entoloma*s.l. (Agaricales) from southern China. Mycological Progress 11(4): 915–925. https://doi.org/10.1007/s11557-012-0807-0

He XL, Li TH, Xi PG, Jiang ZD, Shen YH (2013) Phylogeny of *Entoloma*s.l. subgenus *Pouzarella*, with descriptions of five new species from China. Fungal Diversity 58: 227–243. https://doi.org/10.1007/s13225-012-0212-7

He XL, Peng WH, Gan BC (2015) Morphological and molecular evidence for a new species in *Entoloma* subgenus *Claudopus* from Sichuan Province, southwest China. Mycoscience 56(3): 326–331. https://doi.org/10.1016/j.myc.2014.10.001

He MQ, Chen J, Zhou JL, Ratchadawan D, Hyde KD, Zhao RL (2017) Tropic origins, a dispersal model for saprotrophic mushrooms in Agaricus section Minores with descriptions of sixteen new species. Scientific Reports 7(1): 5122. https://doi.org/10.1038/s41598-017-05203-5

He MQ, Zhao RL, Hyde KD, Begerow D, Kemler M, Yurkov A, McKenzie EHC, Raspé O, Kakishima M, Sánchez-Ramíırez S, Vellinga EC, Halling R, Papp V, Zmitrovich IV, Buyck B, Ertz D, Wijayawardene NN, Cui BK, Schoutteten N, Liu XZ, Li TH, Yao YJ, Zhu XY, Liu AQ, Li GJ, Zhang MZ, Ling ZL, Cao B, Antonín V, Boekhout T, da Silva BDB, De Crop E, Decock C, Dima B, Dutta AK, Fell JW, Geml J, Ghobad-Nejhad M, Giachini AJ, Gibertoni TB, Gorjón SP, Haelewaters D, He SH, Hodkinson BP, Horak E, Hoshino T, Justo A, Lim YW, Menolli Jr N, Mešić A, Moncalvo JM, Mueller GM, Nagy LG, Nilsson RH, Noordeloos M, Nuytinck J, Orihara T, Ratchadawan C, Rajchenberg M, Silva-Filho AGS, Sulzbacher MA, Tkalčec Z, Valenzuela R, Verbeken A, Vizzini A, Wartchow F, Wei TZ, Weiß M, Zhao CL, Kirk PM (2019a) Notes, outline and divergence times of Basidiomycota. Fungal Diversity 99: 105–367. https://doi.org/10.1007/s13225-019-00435-4

He XL, Horak E, Wang D, Li TH, Peng WH, Gan BC (2019b) Descriptions of five new species in *Entoloma* subgenus *Claudopus* from China, with molecular phylogeny of *Entoloma* sl. MycoKeys 61: 1. https://doi.org/10.3897/mycokeys.61.46446

Kalyaanamoorthy S, Bui QM, Wong TKF, von Haeseler A, Jermiin LS (2017) ModelFinder: Fast model selection for accurate phylogenetic estimates. Nature Methods 14(6): 587–589. https://doi.org/10.1038/nmeth.4285

Karstedt F, Bergemann SE, Capelari M (2020) Five *Nolanea* spp. nov. from Brazil. Mycotaxon 135(3): 589–612. https://doi.org/10.5248/135.589

Kaygusuz O, Reschke K, Kaya A, Dima B, Morozova O, Noordeloos ME, Piepenbring M (2024) Morphology and molecular phylogeny of four new species of *Entoloma* (Entolomataceae, Agaricales) from Europe and Western Eurasia. Mycological Progress 23(1): 34. https://doi.org/10.1007/s11557-024-01972-2

Kuo M (2013). *Entoloma incanum*. Retrieved from the MushroomExpert.Com Web site: http://www.mushroomexpert.com/entoloma_incanum.html

Largent DL (1971) Rhodophylloid fungi of the pacific coast (United States) I: Type studies and new combinations of species described prior to 1968. Brittonia 23: 238–245. https://doi.org/10.2307/2805626

Largent DL (1986) How to identify mushrooms to genus. Mad River Press. Eureka, Asunción, 1–5.

Li Y, Li T (2015) Atlas of Chinese Macrofungal Resources. Zhongyuan Farmers Publishing House, Zhengzhou, 1351 pp.

Li JX, He MQ, Zhao RL (2021) A review of *Cystoderma* (Agaricales/Basidiomycota) from China with four new species and two new records. Mycology 13(3): 163–176. https://doi.org/10.1080/21501203.2021.2013969

Niveiro N, Ramirez NA, Baroni TJ, Jimenez S, Popoff O, Albertó E (2021) *Claudopus niger*(Entolomataceae–Basidiomycota), a new species from the Argentinean Atlantic Forest. New Zealand Journal of Botany 60(2): 159–168. https://doi.org/10.1080/00288825X.2021.1955714

Noordeloos ME (1981) Introduction to the taxonomy of the genus *Entoloma* sensu lato (Agaricales). Persoonia-Molecular Phylogeny and Evolution of Fungi 11(2): 121–151.

Noordeloos ME (1985) NotulaeadFloramagaricinamneerlandicam—X-XI. *Entoloma*. Persoonia-Molecular Phylogeny and Evolution of Fungi 12(4): 457–462.

Noordeloos ME, Gates GM, Sachs AW (2012a). The Entolomataceae of Tasmania, vol 22. Springer, New York, 3–18. https://doi.org/10.1007/978-94-007-4679-4

Noordeloos ME, Machiel E, Genevieve MG, Walsmit-Sachs A (2012b) The Entolomataceae of Tasmania, vol 22. Springer, New York. https://doi.org/10.1007/978-94-007-4679-4

Silvestro D, Michalak I (2012) raxmlGUI: A graphical front-end for RAxML. Organisms, Diversity & Evolution 12: 335–337. https://doi.org/10.1007/s13127-011-0056-0

Tedersoo L, May TW, Smith ME (2010) Ectomycorrhizal lifestyle in fungi: Global diversity, distribution, and evolution of phylogenetic lineages. Mycorrhiza 20(4): 217–263. https://doi.org/10.1007/s00572-009-0274-x

Wei SW, Lu BY, Wang Y, Dou WJ, Wang Q, Li Y (2023) Morphology and phylogeny of lyophylloid mushrooms in China with description of four new species. Journal of Fungi (Basel, Switzerland) 9(1): 77. https://doi.org/10.3390/jof9010077

Zhang MZ, Li GJ, Dai RC, Xi YL, Wei SL, Zhao RL (2017) The edible wide mushrooms of *Agaricus* section *Bivelares* from Western China. Mycosphere: Journal of Fungal Biology 8(10): 1640–1652. https://doi.org/10.5943/mycosphere/8/10/4

Supplementary material 1

Sequeneces information used in the phylogenetic analysis

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Data type: xlsx

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